Qualification of Bipolar Plates for Serial Production – BePPel

Nadine Pilinski, Dr. Alexander Dyck, Peter Wagner

03.04.2019

Hannover Fair 2019

DLR Institute of Networked Energy Systems

Project BePPel

- Goals:
  - Definition of the physical parameter „electrical conductivity“
  - Development of standardised measurement procedure
  - Development of measuring device
  - Transfer into a German industrial standard

BePPel

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur

Koordiniert durch: NOW

- Consortium:

ZSW, Fraunhofer ICT, ZBT, Fraunhofer ISE, JÜLICH FORSCHUNGSZENTRUM, DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center – Institute of Networked Energy Systems

- Duration: April 2017 - September 2019

DLR

Standardisation – Current Status

- Existing requirements of German manufacturers of bipolar plates and OEM companies for fuel cells to **standardisations** regarding:

- Electrical conductivity (in-plane and through-plane) and contact resistance
- Thermal conductivity
- Corrosion and aging of BPP
- Mechanical properties of BPP (before and after operation)
- Changes of surface area structure

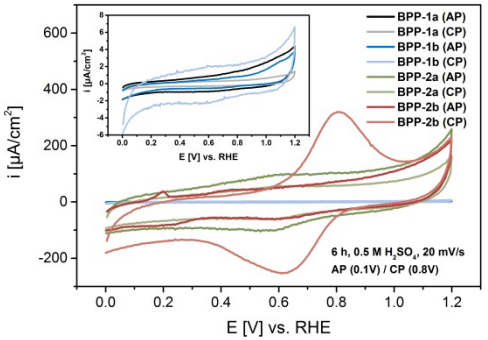
Industry Involvement

Aperam borit
Eisenhuth ElringKlinger fischer eco solutions
Freudenberg Impact Coatings Gräbener
inhouse engineering JenaBatteries Kessen Maschinenbau Marposs
Precors Proton Motor Poco Graphite Dana / Reinz
Schmid Energy Systems Schunk Group SGL Carbon
Tata Steel Von Ardenne Volkswagen

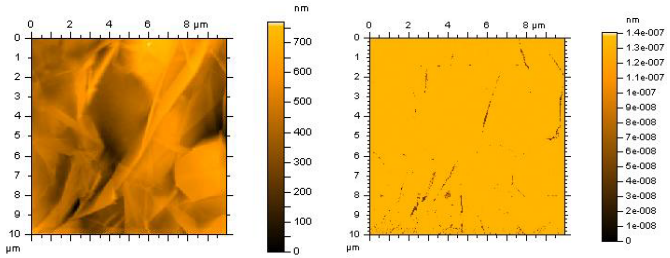
- Cost reduction
- Minimization of faulty components
- Quality improvement
- Data traceability
- Industrial standardisation
- Market transparency

Activities and Results of DLR-VE

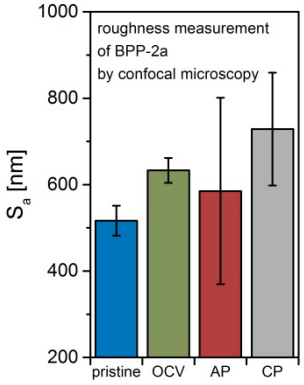
- Corrosion tests of graphite BPP

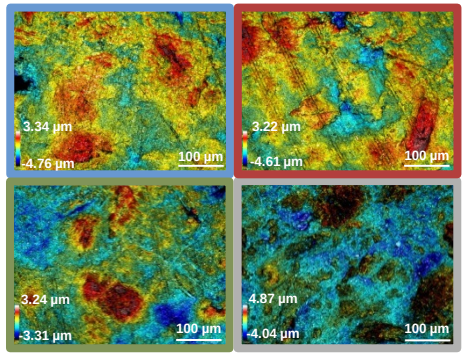


- In-situ measurements in single cell test bench & determination of contact resistances
- Conductivity determination with AFM



- Surface area structure analysis
  - confocal microscopy, AFM, µ-CT, SEM

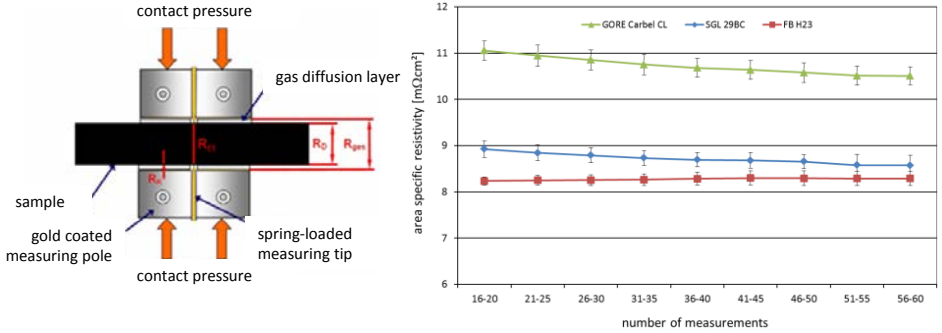




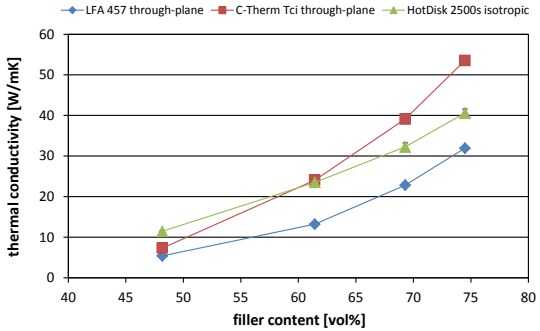
- Transfer of the method into a German industrial standard
- Technical options for implementation of measuring system in the running manufacturing process control for large-scale production

Activities and Results of ZBT

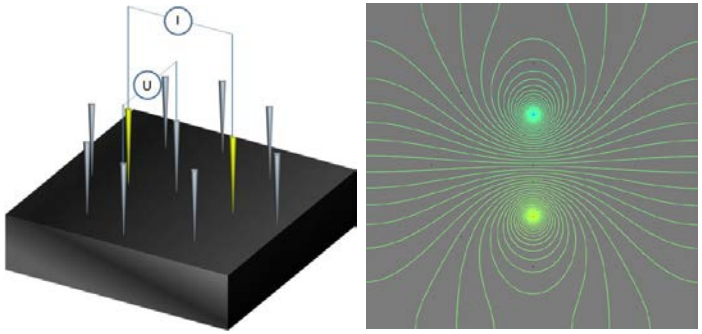
- Reference measurements and analysis of influence factors



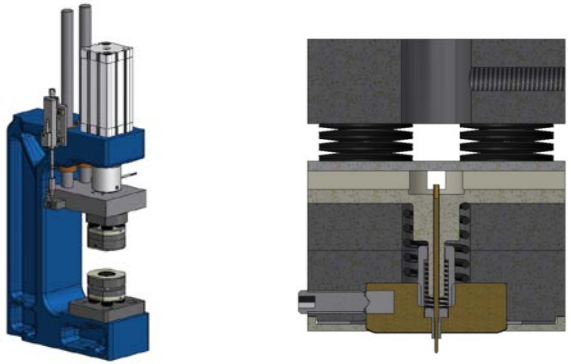
- Comparison of devices for thermal conductivity measurement



- Analysis with Comsol-Multiphysics-Simulation



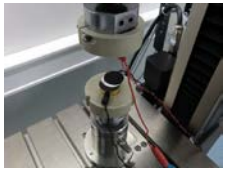
- Development of a measuring device for electrical characterization of BPP



Activities and Results of ZSW

- Through plane resistance measurement of metallic BPP materials:

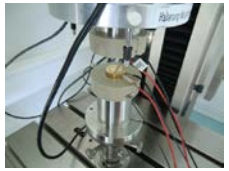
2-pole (uncoated sample)



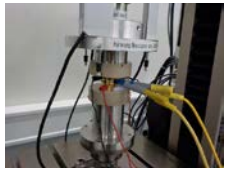
2-pole (gold plated sample)

➢ **Overall resistance**

2/4-pole (ring)



2/4-pole (clips)

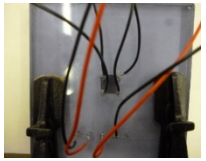


➢ **Overall resistance: bulk+contact**

- Bulk resistance measurement of metallic BPP materials:

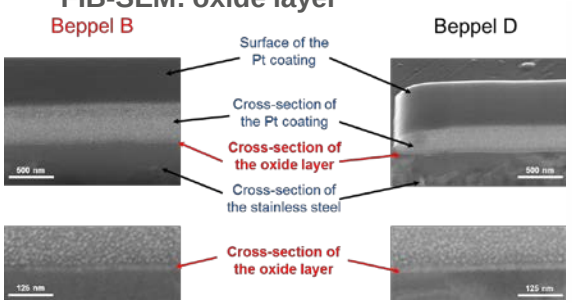
4-point probe

Van-der-Pauw

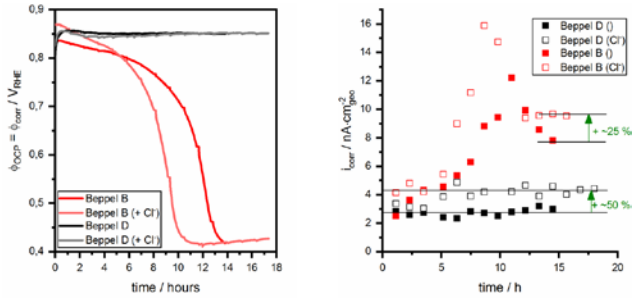


- Characterisations of stainless steel passivation layers:

FIB-SEM: oxide layer



Electrochemistry - corrosion



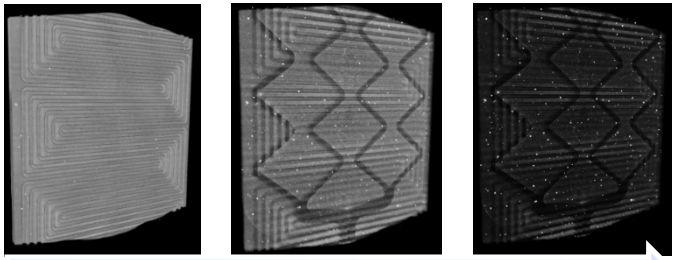
	d_{EIS} [nm]	$d_{FIB-SEM}$ [nm]
Beppel 'D'	28 ±6	26 ±3
Beppel 'B'	12 ±3	17 ±3

➢ **BePPel B shows lower oxide layer thickness and higher corrosion rate**

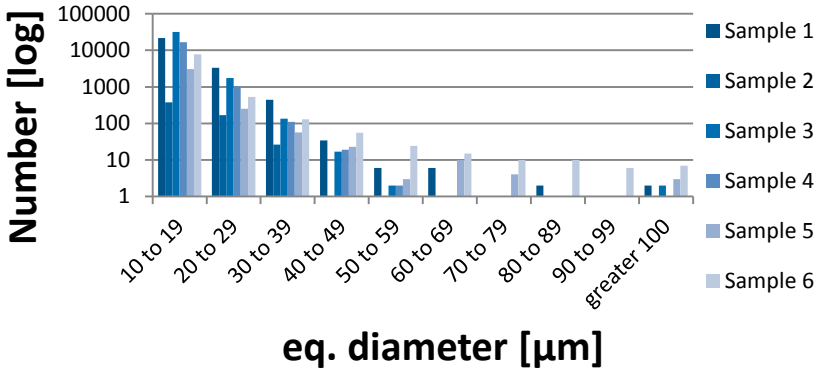
➢ **Same tendency for both methods**

Activities and Results of FZJ

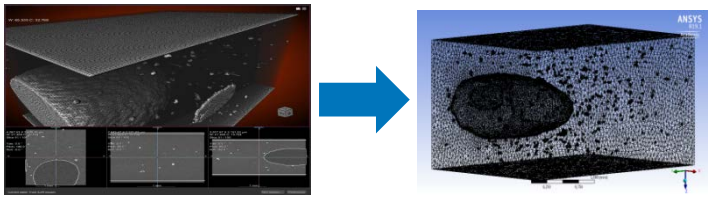
- Investigation of the internal structure of graphite BPP
  - Nano-CT, thermography, electrical conductivity

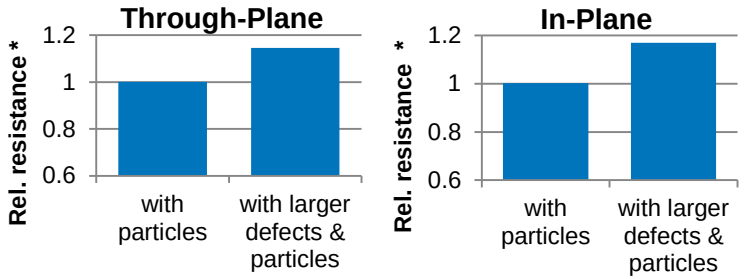


- Analysis of particle and defect distribution



- Development of simulation tools





* related to ideal material

- Experimental validation in fuel cell application
- Quantification of “acceptable” defects

Activities and Results of F-ISE

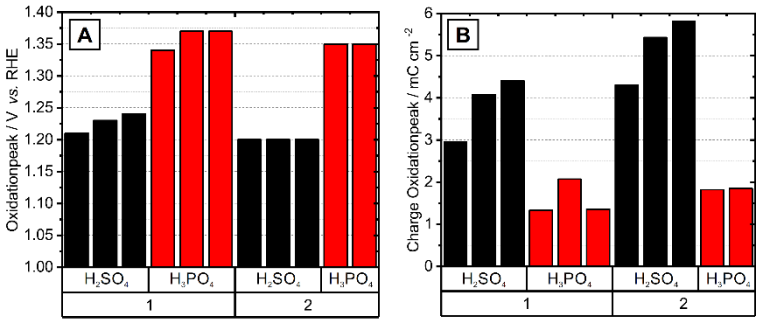
- Ex-situ Corrosion tests of metallic bipolar plates (BPP)
- Cyclic voltammetry: 0.1 mV/s, Ar saturation
- Potentiostatic measurements:
  - Cathodic conditions, O_2 saturation, 0.8 V or 1.4 V
  - Anodic conditions, Ar saturation, 0 V
- Interfacial contact resistance (ICR)
- SEM / EDX
- Elemental analysis (ICP-MS) of electrolyte

ICR of BPP with ISE coating before and after Potentiostatic test at 80 °C, pH = 2.7
DOE target: 10 mΩcm²

	ICR /mΩcm²
fresh	0.0 - 1.0
0.0 V 96 h	0.0 - 1.0
0.8 V 96 h	0.0 - 1.3
1.4 V 1 h	0.0 - 1.3

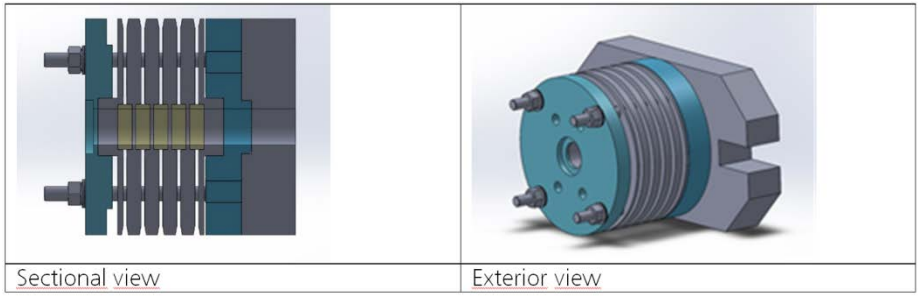
Activities and Results of F-ICT

- Corrosion tests of metallic and graphitic BPP

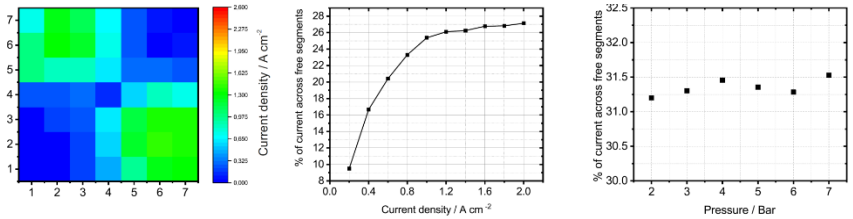


- Measurements of in-plane and through-plane conductivity of graphitic BPP

- Conductivity measurements along production chain (compounding)



- Evaluation of current distribution and effect of defect sites in graphitic materials



Summary and Outlook

- Investigations of metallic and graphitic bipolar plate materials for fuel cells and electrolysers
- Round-Robin test for comparison of electrical conductivity measurements at different institutes and measuring systems nearly completed
- Investigation and verification of measuring methods for determination of electrical conductivity in progress
- Supporting investigations with corrosion measurements, imaging methods and simulation tools
- Guidelines of specifications for measuring device prepared

Thank you very much for your attention!

- **Contact:**

E-Mail: Nadine.Pilinski@DLR.de
Phone: +49 441 99906-314
Website: www.DLR.de/VE
www.projekt-beppel.de

- **Meet us in hall 27, booth D62**

Questions?

Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center
Institute of Networked Energy Systems

ZSW

Fraunhofer ISE

Fraunhofer ICT

ZBT

JÜLICH FORSCHUNGSZENTRUM

Nationales Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (nip)

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur

Koordiniert durch: NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

DLR